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# VEGETAL DEVELOPMENT ON THE SLEEPING CHILD BURN IN WESTERN MONTANA, 1961 to 1973

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## *PESTICIDE PRECAUTIONARY STATEMENT*

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife--if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

# ABSTRACT

In the year following the 1961 Sleeping Child forest fire on the Bitterroot National Forest, Montana, 11 permanent transects were established within the burn. Vegetation development was recorded through 1973, but only four transects were considered indicative of seral forest succession independent of superimposed management activities including salvage logging, cattle grazing, and chemical thinning of tree seedlings.

Tree-seedling attrition amounted to 48 percent of established plants in 11 years and shrub-crown volumes exceeded 2,000 $ft^3$/ acre, while cover at ground level reached nearly 60 percent. Vegetal cover by introduced grasses was an important component of these plant communities for 6 to 8 years.

Major modifications in plant community structure resulted from management activities, but none of the existing communities are considered completely atypical.

# INTRODUCTION

During the period August 4 through 9, 1961, more than 28,000 acres of high-altitude forest on the Bitterroot National Forest burned in a high-intensity, lightning-caused wildfire. With the exception of some small islands of unburned forest, the general visual impression was that all vegetation had been reduced to blackened stems and ashes (fig. 1). At the time, the Sleeping Child fire was the single largest forest fire in the Northern Rockies in more than 20 years. Thus, it presented a unique opportunity to record postfire vegetal recovery and development in the upper montane and subalpine forest zones of Montana.

*Figure 1.--Transect SC01, August 1962. One year after the Sleeping Child fire.*

During the summer of 1962, 12 permanent transects were established near the center of the burn in the area around the Sleeping Child, Rye Creek, and Martin Creek Divides. One transect was located on a patented mining claim, and at the request of the operator it was removed. The remaining 11 transects represented all aspects, except due east, at altitudes between 6,400 and 7,200 feet. At these elevations on the Bitterroot National Forest, lodgepole pine is the dominant tree species, but forest communities are mostly classified as *Abies lasiocarpa/Xerophyllum tenax* habitat type.[1] Transects above 7,000 feet appear to be *Vaccinium scoparium* phase while those at lower elevations are *Vaccinium globulare* phase.

The initial objectives of this study specified annual sampling for a period of 10 to 15 years to document early postfire vegetal development in a predominantly lodgepole pine forest. However, and unfortunately for the initial study objectives, the Sleeping Child burn also created a series of unusual land management problems. Postfire rehabilitation of the high-altitude watershed was considered a management necessity. Immediate salvage logging was required to prevent the loss of a substantial volume of timber. The growth of grasses and forbs provided an opportunity to relieve grazing pressure on cattle allotments elsewhere on the Bitterroot National Forest, and the obvious overstocking of lodgepole pine seedlings led to intensive efforts to reduce tree densities throughout the burn. Management personnel did attempt to mark and protect the research transects, but changes in staffing and the pressures of project planning have resulted in a continuous attrition of undisturbed sample areas. At the completion of the 1973 field season, there were only two transects remaining which had not been compromised in one or more ways.

Although the collected information does not represent undisturbed postfire forest succession, the study still has considerable value. Each of the transects provides a case study of forest vegetation development, and comparison of disturbed and undisturbed transects provides both an evaluation of treatment effects and a demonstration of stability and assimilative capacity in these high-altitude forest communities. Finally, and despite some fairly substantial short-term modifications, there is an overall consistency of pattern which suggests that some facets of early seral succession can still be predicted from the available data.

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[1]Pfister, Robert D., Bernard L. Kovalchik, Stephen F. Arno, and Richard C. Presby. 1974. Forest habitat types of Montana. Intermountain Forest and Range Experiment Station and Northern Region, USDA Forest Service, Missoula, Montana. 167 p. (mimeo).

# METHODS

Transects were located to provide a range of slopes, aspects, and altitudes present in the burn (table 1). Insofar as possible, the sampling areas were confined to uniform topography. Each transect consisted of 10 circular plots, 23.55 feet in radius (0.04 acre), with a paired 2- by 2-foot plot inside. Large plot centers were spaced at 50-foot intervals and permanently marked with 3/8-inch steel pins. Secondary steel pins, located 10 feet uphill from the large plot centers, provided permanent location points for the small plots.

Vegetation sampling in the large plots consisted of a total count, by species, of all trees and shrubs more than 6 inches tall. In addition, 5 to 10 random shrubs of each species in each plot were measured on two dimensions of the plant crown (a, b) and height (h) to the nearest inch. These data were converted to crown volume ($V = \pi abh/4$) and the averages for measured plants were applied to the count data to obtain crown-volume estimates for the transect. Data recorded in the 2- by 2-foot plots included tree seedling density, vegetal cover to the nearest quarter-plot, and frequency of occurrence for all species under 18 inches tall.

Transects were established during the first postfire growing season (1962) and sampled annually through 1967 and semiannually thereafter through 1973. Six of the transects were also sampled in 1970 in an attempt to assess herbicide effects.

All data in this paper are presented in English units. Conversion to metric units requires the following constants:

| | |
|---|---|
| Inches × 2.540 | = centimeters |
| feet × 0.305 | = meters |
| $f^3$ × 0.028 | = $m^3$ |
| $f^3$/acre × 0.070 | = $m^3$/hectare |
| acres × 0.405 | = hectares |
| density/acre × 2.471 | = density/hectare |

Table 1.--*Physical descriptions of transects, Sleeping Child burn*

| | Transect | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| Aspect (azimuth) | 10 | 205 | 355 | 335 | 315 | 5 | 200 | 125 | 205 | 50 | 285 |
| Altitude (100 ft) | 72 | 72 | 66 | 64 | 65 | 67 | 68 | 71 | 68 | 70 | 64 |
| Slope (percent) | 40 | 35 | 35 | 30 | 20 | 25 | 20 | 45 | 40 | 47 | 30 |

# MANAGEMENT ACTIVITIES AND TREATMENTS

The Darby and Sula Ranger Districts have had active watershed rehabilitation, timber salvage, timber stand improvement, deadwood sales, and grazing programs on the Sleeping Child burn. In addition, the burn has been an important source of firewood, corral poles, and fenceposts for Ravalli County residents. Insofar as records are available, these activities are summarized by year in table 2.

Table 2.--*Summary of management actions and other activities on the Sleeping Child burn, 1962 to 1973*[1]

| Activity | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aerial seeding[2] | A | | | | | | | | | | | |
| Tree planting, acres | 500 | | | | 30 | | | | | | | |
| Road construction, miles | 200 | A | | | | | | | | | | |
| Terracing, acres | 1,280 | A | | | 30 | A | | | | | | |
| Check dams | 1,400 | | | | | | | | | | | |
| Stream clearance, miles | 22 | | | | | | | | | | | |
| Timber salvage, MMBF | 76 | 10 | 4 | 3 | | | | | | | | |
| Poles and firewood | | A | A | A | A | A | A | A | A | A | A | A |
| Deadwood sales, MMBF | | | | | | A | A | A | A | A | [4]105 | 10-15 |
| Christmas trees, bales | | | | | | | | 100 | 100 | 100 | 100 | 100 |
| Mechanical thinning[3] | | | | A | | | | | | | | |
| Chemical thinning, acres | | | | | 126 | 175 | 851 | 1,738 | | | | |
| Mistletoe control, acres | | | | | | 3,132 | | | | | | |
| Cattle, 3 to 4 months | | | 430 | 356 | 408 | 525 | 913 | 787 | 848 | 705 | 610 | 563 |

[1] "A" where an activity occurred but no total was recorded.
[2] 180 tons of smooth brome, orchardgrass, hard fescue, annual rye, timothy and Dutch white clover applied by helicopter to the total burned area. These species were recorded on all transects.
[3] Contract defaulted.
[4] Total deadwood sales through 1972.

With few exceptions, it is not possible to describe the specific levels of treatment that influenced vegetation development on transects. Salvage logging, and pole and firewood cutting were usually obvious, but cattle use was only recorded when extremely heavy. Herbicide projects, in particular, presented many situations in which chemical sprays[2] were applied by helicopter within one-half mile or less. Two transects were inside the boundaries of spray projects, herbicide-drift effects were either recorded or indicated by curled, brown leaves on vegetation of seven transects, and eight transects were close enough to have received chemical drift even though no effects were seen. Known or suspected treatments for each transect are summarized in table 3.

Table 3.--*Summary of disturbances to vegetal development on 11 permanent transects, Sleeping Child burn, 1972 to 1973*

| | Transect | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 01 | 02 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 |
| Aerial seeding[1] | 1962 | 1962 | 1962 | 1962 | 1962 | 1962 | 1962 | 1962 | 1962 | 1962 | 1962 |
| Posts or firewood[2] | | | 1967 | | | 1967 | | | | | 1966 |
| Pole sale | | | | 1965 | 1967 | 1969<br>1970 | | | | | |
| Road construction | | | | | 1967 | 1967<br>1970 | | | | | |
| Chemical project[3] | | | | | 1969 | | | | | 1967 | |
| Recorded drift effect | | | 1968 | 1966 | 1966 | 1967 | 1967<br>1969 | | | 1968 | 1969 |
| Potential drift | | | 1969 | [4]1967(6)<br>1969 | 1967(3) | 1966<br>1967(6)<br>1969 | 1966<br>1967(5) | 1968<br>1969 | 1969 | | 1966<br>1967(3) |
| Heavy cattle use[5] | | | | | 1965 | 1964<br>to<br>1973 | 1965<br>1969<br>1973 | 1965 | | | |

[1] If the distribution of seed was uniform, about 14 lb per acre.

[2] Post or firewood cutting was a relatively minor disturbance as contrasted to a pole sale which usually involved a bulldozer or some other major equipment.

[3] Treatments have been separated to indicate whether the transect was inside a spray area boundary, adjacent to a spray project, or simply within one-half mile of a project.

[4] Number in parentheses indicates the number of times the transect was within one-half mile of a spray project.

[5] Cattle use recorded only where trampling and grazing effects were obvious.

[2]Exploratory applications in 1966 and 1967 involved seven chemicals and 35 formulations. Project applications in 1968 and 1969 used 2,4-D ester and Dacamine 4-D.

# TREATMENT EFFECTS

Of the 11 transects that constitute the sample for this study, all were affected by the aerial seeding for watershed protection and only two remained otherwise undisturbed during the 12 years of postfire recovery. Two additional transects were compromised in relatively minor ways, but seven transects received a variety of unplanned treatments, including disturbance by pole sales, cattle grazing, and herbicide applications intended to reduce lodgepole pine densities.

Examination of vegetal development on individual transects reveals several very substantial modifications following these disturbances. On some transects, in a single year, and as an apparent direct result of disturbance, tree densities declined by as much as 60,000 per acre (table 4), shrub-crown volumes were reduced by more than 50 percent (fig. 2), and one-third of the ground-level vegetal cover was removed (fig. 3).

Table 4.--*Tree densities on Sleeping Child transects 1962 to 1973*

| Transect | 1962 | 1963 | 1964 | 1965 | 1966 | 1967 | 1969 | 1971 | 1973 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | THOUSANDS OF TREES PER ACRE[1] | | | | |
| *SC01 | T[2] | T | T | T | T | T | T | 0.1 | 0.1 |
| *SC02 | 4.4 | 4.4 | 3.3 | 4.4 | 4.4 | 4.5 | 2.2 | 3.8 | 3.9 |
| SC04 | 44.6 | 46.8 | 43.6 | 45.7 | 45.7 | 38.1 | 39.0 | 39.1 | 39.6 |
| SC05 | 8.7 | 17.4 | 17.4 | 14.2 | 10.9 | 8.7 | 9.4 | 11.1 | 14.9 |
| SC06 | 75.1 | 78.4 | 69.7 | 64.3 | 58.8 | 51.2 | 52.0 | 34.4 | 35.6 |
| SC07 | 148.1 | 159.0 | 151.4 | 148.1 | 145.9 | 129.7 | 119.8 | 58.3 | 69.7 |
| SC08 | 6.5 | 7.6 | 7.6 | 7.6 | 7.6 | 4.7 | 4.2 | 1.6 | 1.7 |
| *SC09 | 2.2 | 2.2 | 2.2 | 2.2 | 1.1 | 1.2 | 1.3 | 0.3 | 0.4 |
| *SC10 | 29.4 | 26.1 | 26.1 | 27.2 | 19.6 | 12.6 | 15.1 | 16.5 | 15.4 |
| SC11 | 19.6 | 19.6 | 16.3 | 16.3 | 14.2 | 9.0 | 1.4 | 1.8 | 3.3 |
| SC12 | 9.8 | 8.7 | 7.6 | 9.8 | 9.8 | 10.0 | 9.9 | 9.7 | 10.2 |
| Average | 31.7 | 33.0 | 31.4 | 30.9 | 28.9 | 24.5 | 23.1 | 16.1 | 17.7 |
| | | | | | THOUSANDS PER ACRE OVER 18 INCHES TALL | | | | |
| *SC01 | | | | | | | | 0.1 | 0.1 |
| *SC02 | | | | | | 0.1 | 1.2 | 2.7 | 3.9 |
| SC04 | | | | | | | 0.9 | 4.2 | 8.0 |
| SC05 | | | | | | | 0.7 | 3.5 | 6.2 |
| SC06 | | | | | | 0.1 | 1.9 | 2.8 | 5.2 |
| SC07 | | | | | | 0.1 | 2.2 | 10.4 | 15.2 |
| SC08 | | | | | | 0.3 | 0.9 | 1.6 | 1.7 |
| *SC09 | | | | | | 0.1 | 0.2 | 0.3 | 0.4 |
| *SC10 | | | | | | 0.6 | 4.2 | 7.8 | 11.1 |
| SC11 | | | | | | 0.3 | 0.3 | 0.7 | 1.1 |
| SC12 | | | | | | 0.2 | 1.1 | 4.2 | 5.9 |

[1] Estimates prior to 1967 based on projections from 10 small plots (4 $ft^2$). Variance in these data is extremely high because a single seedling in these plots projects to 1,089 per acre. After 1967, the data include trees over 18 inches tall from the 0.04-acre plots as listed separately in the lower half of the table.

[2] "T" = less than 50 trees per acre.

* Transects considered to be undisturbed.

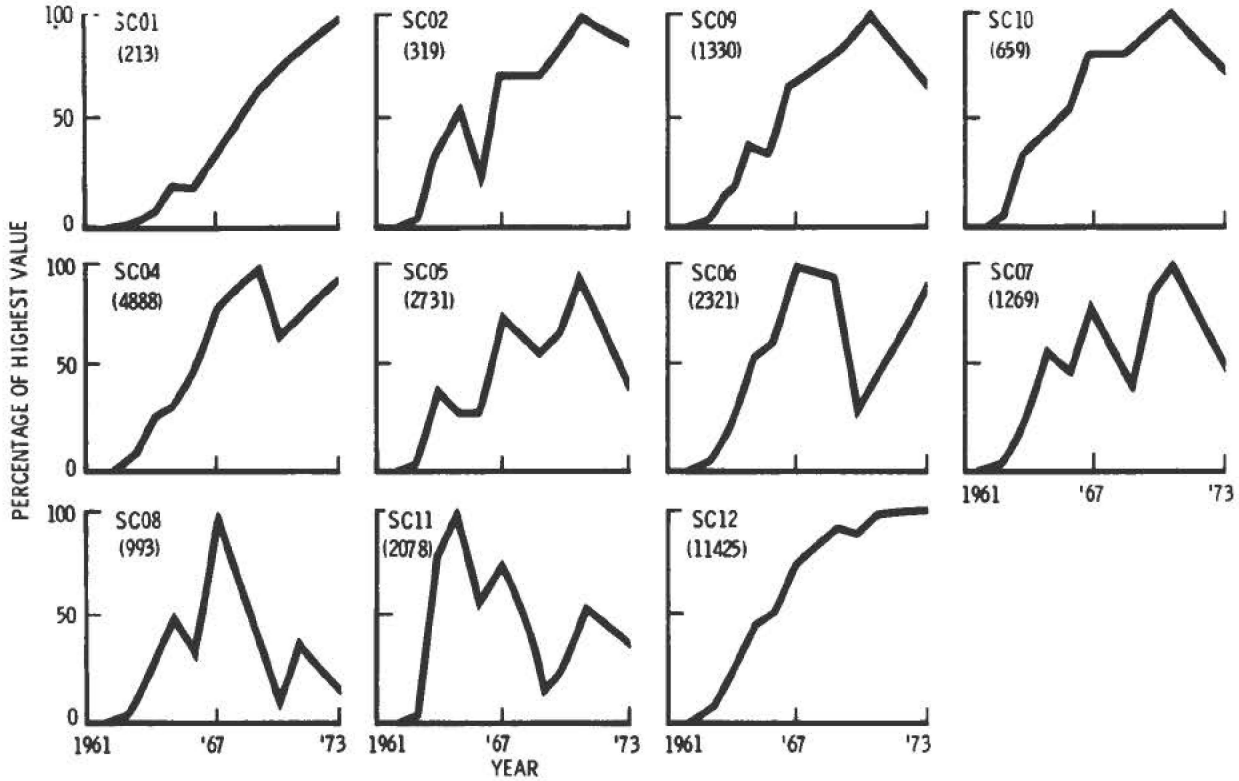


*Figure 2.--Shrub-crown volume, Sleeping Child transects, 1961-1973, as a percentage of highest value recorded. Scale peak, $ft^3$/acre, is indicated in parentheses.*

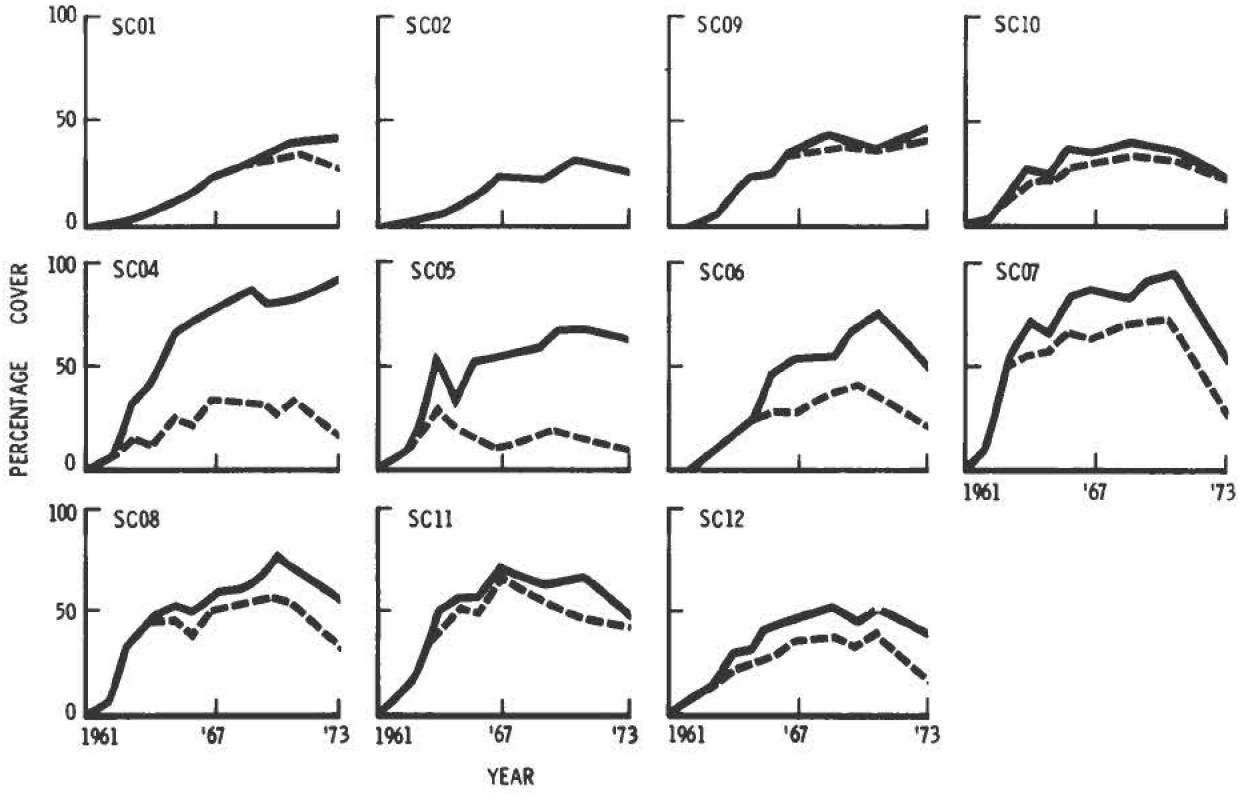


*Figure 3.--Percentage vegetal cover (solid line) and vascular cover only (dashed line), Sleeping Child transects, 1961-1973.*

Vegetation losses of this magnitude might appear to be disastrous, but long-term evaluation provides a somewhat less conclusive assessment. Attrition of lodgepole pine seedlings would probably have occurred without treatment, and, in no case did a treatment reduce tree densities to the levels expected at forest maturity; many of the shrub-crown declines had been recovered; and vegetal cover on all transects had apparently stabilized by 1970, although community structure was very much modified. Moreover, despite very substantial fluctuations, vegetation development trends for the whole burn appear to be relatively consistent. Thus, in the following discussion I will attempt to evaluate treatment effects by estimating the amount of vegetation which would have been present in the absence of treatments and by comparing trends on the seven disturbed transects with the four transects which received little or no treatment.

To the degree possible, table 5 summarizes the composition, density, and volume changes of vegetation on each transect following recorded treatments, and figures 4 and 5 provide representative examples of vegetal development over the 12 growing seasons of investigation. In each case, any losses in vegetation during the year of treatment or the first year following treatment were assumed to be treatment caused. Because there were no disturbances other than cattle grazing on any transect after 1969, I have assumed that the failure of a species to regain a pretreatment level reached prior to 1970 represents the minimum deficit due to treatments. Ground-level cover deficits will be shown to have occurred at the species level, but none are listed in table 5 because total cover was not significantly reduced.

## Tree Densities

The majority of tree seedlings recorded on the Sleeping Child burn were lodgepole pine established in the first growing season. However, some germination took place after the plots were sampled in 1962, and the best estimate of the number of seedling trees established has been taken as the greatest number recorded in either of the first 2 years (table 4). Seedling densities on individual transects ranged from about 100 to nearly 160,000 per acre, with the average for all transects in excess of 34,000. Recorded losses were low for a few years, increased substantially after 1966, and were as high as 80 percent on a few transects. The average annual attrition rate for 11 years was 5.77 percent but there were still 17,700 trees per acre alive in 1973 (fig. 6).

In view of the number of tree seedlings established, an overall loss of 48 percent in the decade can certainly be considered normal. Continuation of the current attrition rate will reduce average tree density to about 1,000 to 1,500 per acre between 50 and 60 years, and even the most conservative estimates of future development would suggest losses of this magnitude can be expected. In consideration of the large die-off already recorded, any conjecture about the course of tree development in the absence of pole sales and chemical thinning must be highly speculative. However, comparison of survival and attrition on the seven disturbed transects with the four undisturbed transects does lead to some surprising conclusions.

For all trees on the four undisturbed transects, annual attrition was 5.26 percent and survival to 1973 was 55 percent. This is not significantly different than the 5.83 percent attrition and 52 percent survival on the seven transects that were eventually disturbed. However, the level of survival on disturbed transects was certainly unexpected considering that at least eight different reductions in seedling density ranging as high as 80 percent were recorded following pole sales or herbicide applications. It is even more surprising when the vegetal composition of the two groups of transects is considered. In the year before management activities were initiated (1965), those transects eventually disturbed averaged five times as many tree seedlings, seven times as much shrub crown, and nearly three times as much vegetal cover as the undisturbed transects. This amount of competing vegetation should have caused tree seedling attrition independent of management activity, and it seems logical to ask whether such competition was, in fact, significant.

Table 5.--*Single-year declines in vegetation*[1] *attributed to various treatments*[2] *and estimated deficit in 1973*[3]

| Transect | Treatment and single-year decline per acre | Estimated minimum deficit in 1973 |
|---|---|---|
| SC01 | No treatments recorded | |
| SC02 | No treatments recorded | |
| SC04 | 1968-69 herbicide: 2,209 $ft^3$ alder, menziesia, and vaccinium, 6 percent cover of *Vaccinium scoparium* | 829 $ft^3$ alder<br>490 $ft^3$ menziesia |
| SC05 | 1965 pole sale and 1966 herbicide: 6,500 lodgepole, 415 $ft^3$ spiraea, 18 percent cover<br>1967 herbicide: 390 $ft^3$ spiraea, vaccinium<br>1969 herbicide: 353 $ft^3$ vaccinium | 6,500 lodgepole |
| SC06 | 1965 cattle and 1966 herbicide: 130 $ft^3$ willow, spiraea<br>1967 pole sale and herbicide: 7,700 lodgepole, 271 $ft^3$ rose, vaccinium<br>1969 herbicide: 17,600 lodgepole, 1,434 $ft^3$ spiraea, vaccinium, shepherdia, willow, 3 other species | 25,300 lodgepole<br>304 $ft^3$ shepherdia<br>280 $ft^3$ vaccinium<br>168 $ft^3$ willow<br>33 $ft^3$ 3 other species |
| SC07 | 1964-1966 cattle and herbicide: 198 $ft^3$ spiraea, vaccinium<br>1967 herbicide and cattle: 16,200 lodgepole, 345 ft vaccinium<br>1969-70 herbicide, pole sale, and cattle: 71,400 lodgepole, 118 $ft^3$ spiraea | 87,600 lodgepole<br>157 $ft^3$ spiraea |
| SC08 | 1965 cattle: 182 $ft^3$ spiraea, vaccinium<br>1967 herbicide: 3,400 lodgepole, 625 $ft^3$ spiraea, vaccinium, 3 other species<br>1969 herbicide and cattle: 2,600 lodgepole, 287 $ft^3$ vaccinium, spiraea, 3 other species; 8 percent cover of lupine | 6,000 lodgepole<br>434 $ft^3$ spiraea<br>119 $ft^3$ vaccinium<br>82 $ft^3$ other species |
| SC09 | 1965 cattle: 48 $ft^3$ spiraea, vaccinium<br>1967 herbicide: 9 $ft^3$ vaccinium | None |
| SC10 | 1969 herbicide: 27 $ft^3$ spiraea | 27 $ft^3$ spiraea |
| SC11 | 1967-68 herbicide: 12,800 lodgepole, 1,291 $ft^3$ spiraea, vaccinium, serviceberry, 2 other species, 8 percent cover of lupine | 12,800 lodgepole<br>354 $ft^3$ vaccinium<br>40 $ft^3$ spiraea<br>40 $ft^3$ serviceberry<br>6 $ft^3$ willow |
| SC12 | 1966 herbicide: 242 $ft^3$ spiraea, vaccinium<br>1967-1969 herbicide: 2,367 $ft^3$ alder, spiraea, vaccinium, rose | 343 $ft^3$ alder<br>181 $ft^3$ spiraea |

[1] Scientific names follow Hitchcock, C. Leo, and Arthur Cronquist. 1973. Flora of the Pacific Northwest. Univ. Wash. Press, Seattle, 730 p.

lodgepole - *Pinus contorta*
alder - *Alnus sinuata*
menziesia - *Menziesia ferruginea*
rose - *Rosa gymnocarpa*
serviceberry - *Amelanchier alnifolia*
shepherdia - *Shepherdia canadensis*
spiraea - *Spiraea betulifolia*
vaccinium - *Vaccinium globulare*
willow - *Salix scouleriana*
lupine - *Lupinus sulphureus*

[2] Based on the assumption that an immediate decline or a decline within 1 year following treatment was treatment caused.

[3] Based on the failure of a species to at least recover the pretreatment level. Tree losses are also indicated even though natural attrition also occurred and no recovery was expected. Herbaceous cover deficits appear to have been recovered by species replacement and are not listed here.

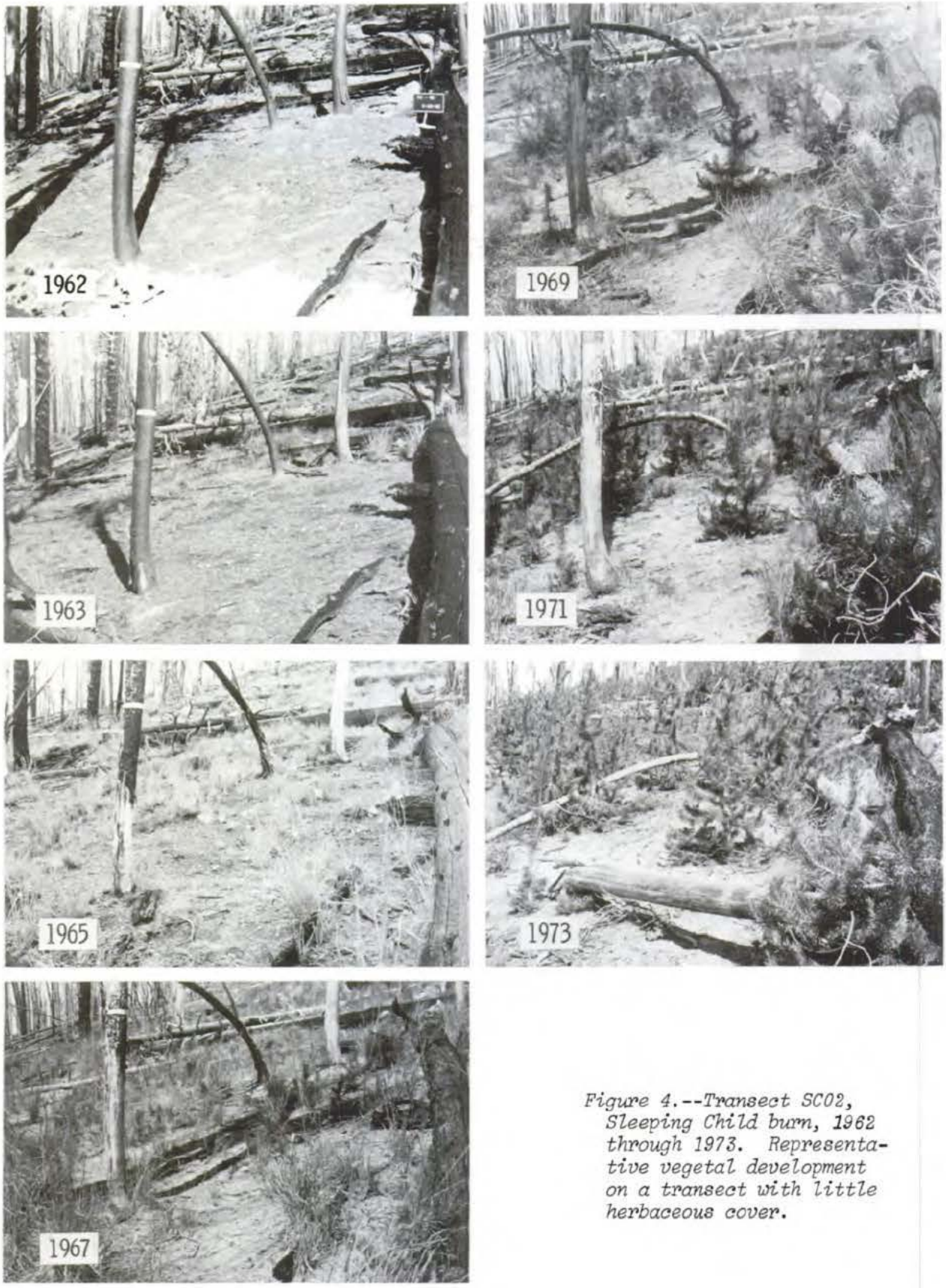


*Figure 4.--Transect SC02, Sleeping Child burn, 1962 through 1973. Representative vegetal development on a transect with little herbaceous cover.*

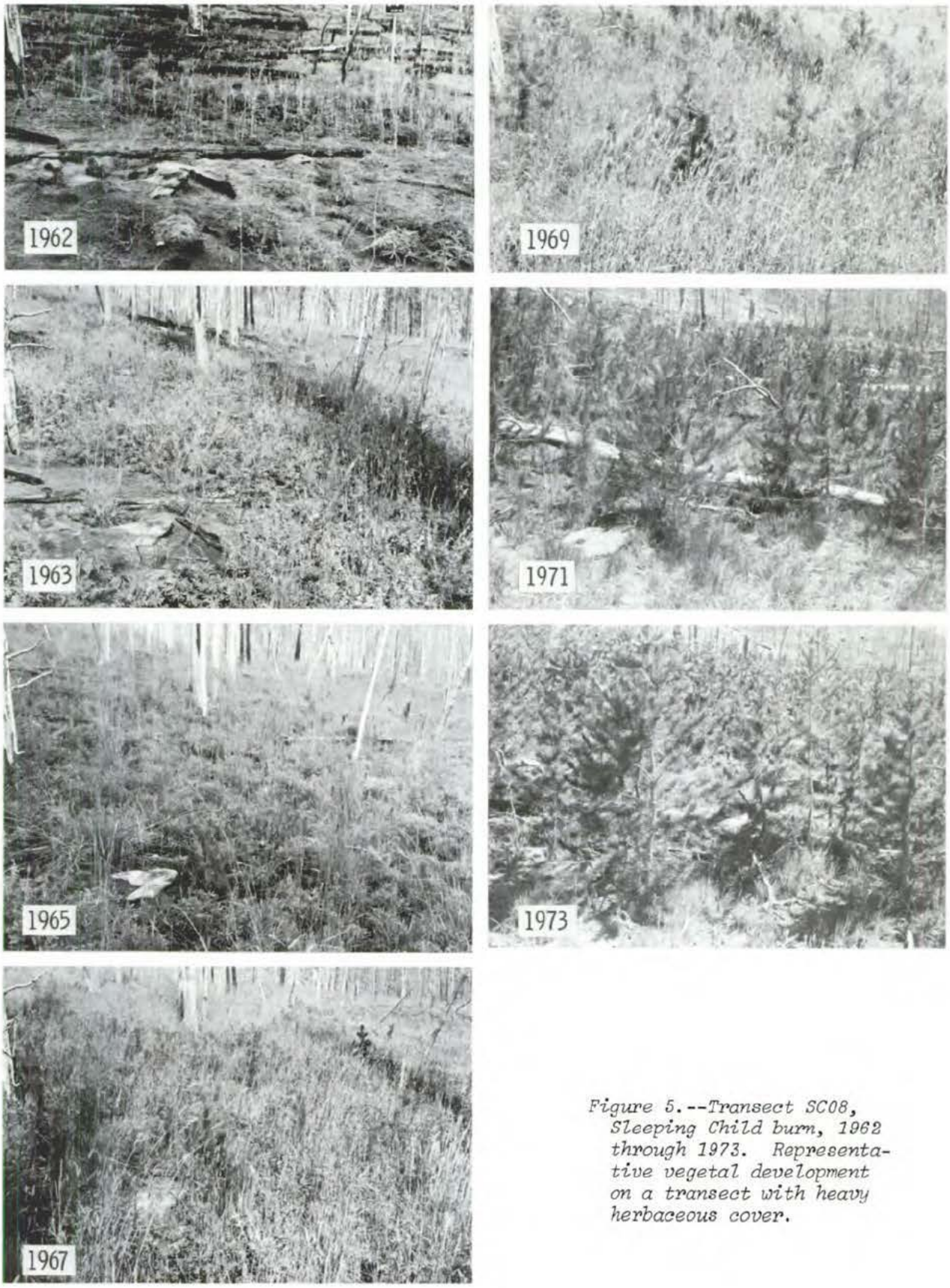


*Figure 5.--Transect SC08, Sleeping Child burn, 1962 through 1973. Representative vegetal development on a transect with heavy herbaceous cover.*

*Figure 6.--Transect SC10, Sleeping Child burn, August 1973. Over 15,000 lodgepole pine trees per acre was average for the burned area.*

Unfortunately, these data do not suggest a method for delineating the causes of seedling attrition and, in fact, provide very little evidence that recorded disturbances even occurred. The Spearman rank order correlation between seedling density and surviving tree density is $r_s = 0.918$. Moreover, the correlation between seedling density and tree dominance expressed as the percentage of trees over 18 inches tall was $r_s = -0.895$. Thus, trees apparently survived in proportion to postfire seedling densities and, more important, achieved dominance in inverse proportion to seedling densities.

Shrubs and herbaceous cover may also have contributed to these relationships, but the correlations between these variables and tree densities were not significant; and I am unwilling to assign much importance to the relationships with dominance. Tree dominance in 1973 was negatively correlated with both shrub and herbaceous cover as recorded in 1965; but there were enough reductions in shrub and herbaceous cover during the study to suggest that survival of nondominant seedlings may have been enhanced by the removal of competition.

## Shrub-Crown Volumes

The average shrub-crown volume for 11 transects in 1973 was 2,076 $ft^3$/acre, but the seven transects on which disturbance effects were recorded averaged nearly 623 $ft^3$/acre less shrub crown than minimum predictions of undisturbed development (table 5). It is estimated that shrub-crown volumes would have reached at least 2,700 $ft^3$/acre by 1973 on the average Sleeping Child transect in the absence of disturbance.

It is not really possible to determine whether this apparent loss of at least one-fourth of shrub-crown volume will be important in the long term. Forty percent of the estimated deficit is the result of alder dieback on two transects. In both cases, the

alder was reduced but not removed from the shrub community. Another third of the deficit is about equally divided between *Vaccinium globulare* and *Spiraea betulifolia*. In general, herbicides appeared to have a greater influence in reducing vaccinium, while cattle grazing had a greater influence in depressing spiraea. However, on no transect was either species permanently removed. Reactions of other shrub species were too variable to indicate relative susceptibility to herbicides, but the data generally provided no evidence that dominant species were permanently removed.

Recovery of the deficit shrub crown, on the other hand, is not necessarily indicated in the data. For 2 years following the last disturbance, shrub crown increased at a greater rate where disturbance had occurred. However, changes in shrub crown were virtually identical on disturbed and undisturbed transects between 1971 and 1973 and it appears that further recovery cannot be predicted.

## Vegetal Cover

Superficially, the percentage vegetal cover at ground level was not greatly influenced by management disturbances (fig. 3). To the degree that 110 plots on 11 transects are representative of the total burn, the data indicate about 4 percent vegetal cover in the first growing season, rising to 30 percent in 3 years, and 50 percent at 6 years. Then, following a 4-year rise to 58 percent, vegetal cover declined by 8 percent (table 6) as a result of a decline in seeded grasses. A more complete discussion of the fate of these species will be presented later.

Table 6.--*Percentage vegetal cover, average for 11 transects, 1962 to 1973*

| Source | Succession Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| All vegetation under 18 inches | 4.1 | 17.7 | 31.8 | 35.7 | 44.5 | 50.5 | -- | 53.2 | -- | 58.2 | -- | 50.8 |
| Vascular vegetation | 4.1 | 16.1 | 23.9 | 28.4 | 29.6 | 36.1 | -- | 38.2 | -- | 38.0 | -- | 27.1 |
| Undisturbed | 0.6 | 5.6 | 10.6 | 16.3 | 21.3 | 28.1 | -- | 30.0 | -- | 32.5 | -- | 28.1 |
| Disturbed | 6.1 | 22.1 | 31.4 | 35.4 | 34.3 | 40.7 | -- | 43.2 | -- | 41.1 | -- | 26.4 |
| Introduced species | 2.7 | 9.0 | 10.6 | 12.0 | 12.6 | 14.5 | -- | 13.8 | -- | 13.3 | -- | 4.7 |
| *Dactylus glomerata* | 0.9 | 3.0 | 4.3 | 7.0 | 8.3 | 8.9 | -- | 8.6 | -- | 8.6 | -- | 1.8 |
| *Festuca ovina* | 0.5 | 2.1 | 2.6 | 2.0 | 2.2 | 2.9 | -- | 2.6 | -- | 2.9 | -- | 2.0 |
| *Phleum pratense* | 0.6 | 2.1 | 3.0 | 2.5 | 1.7 | 1.9 | -- | 1.8 | -- | 1.3 | -- | 0.7 |
| *Bromus inermis* | 0.2 | 1.0 | 0.5 | 0.5 | 0.5 | 0.9 | -- | 0.9 | -- | 0.6 | -- | 0.4 |
| *Secale cereale* | 0.5 | 0.5 | 0.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| *Trifolium repens* | 0.1 | 0.3 | 0.1 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Native species | 1.4 | 7.1 | 13.3 | 16.4 | 17.0 | 21.6 | -- | 24.4 | -- | 24.7 | -- | 22.3 |
| *Vaccinium scoparium* | 0.2 | 0.9 | 1.9 | 2.3 | 2.5 | 3.9 | -- | 3.2 | -- | 5.1 | -- | 4.4 |
| Undisturbed | 0.3 | 0.7 | 2.2 | 3.4 | 4.4 | 6.8 | -- | 6.4 | -- | 10.8 | -- | 9.6 |
| Disturbed | 0.1 | 1.0 | 1.8 | 1.7 | 1.4 | 2.2 | -- | 1.3 | -- | 1.8 | -- | 1.4 |
| *Lupinus sulphureus* | 0.6 | 0.9 | 2.0 | 3.6 | 2.9 | 3.4 | -- | 2.5 | -- | 1.1 | -- | 0.4 |
| *Xerophyllum tenax* | 0.1 | 0.5 | 0.6 | 1.2 | 1.3 | 1.4 | -- | 1.5 | -- | 2.0 | -- | 2.7 |
| *Calamagrostis rubescens* | 0.1 | 0.7 | 1.3 | 1.3 | 1.3 | 2.1 | -- | 3.1 | -- | 3.7 | -- | 4.2 |
| *Epilobium angustifolium* | 0.1 | 0.3 | 0.7 | 0.7 | 0.7 | 0.5 | -- | 0.4 | -- | 0.5 | -- | 0.2 |
| *Carex* spp. | 0.1 | 0.5 | 0.9 | 0.9 | 0.8 | 1.4 | -- | 2.0 | -- | 2.2 | -- | 2.0 |

Closer examination of the data suggests that while total vegetal cover was not influenced, treatments may have substantially modified the structure of this vegetation layer. On the four transects considered to be undisturbed, vascular vegetation made up 90 percent of all low vegetal cover until dropping to 85 percent in the final year of study. By contrast, mosses and lichens became a progressively important component of cover on the disturbed transects until they exceeded 50 percent in the final year. Because the sampling system identifies bryophyte cover only when not overtopped by vascular vegetation, it cannot be shown that mosses and lichens were increased by treatments. It is suggested, however, that vascular cover was significantly reduced.

In the period prior to 1966, those transects eventually disturbed averaged more than twice as much vascular cover as the undisturbed transects. However, during the 4 years of management activity, vascular development was much slower on disturbed areas, and by 1973 the amount of vascular cover was nearly identical for treated and untreated areas. During the same time period, the ratio of shrub-forb cover to graminoids and conifers increased from 0.63 to 1.10 on undisturbed areas and dropped from 0.54 to 0.43 on treated areas.

If it is assumed that low cover should have been at least 85 percent vascular, or that vascular cover should have been at least half forbs and shrubs, the minimum calculated deficit on treated transects can be estimated between 11 and 25 percent cover. Again, it is not possible to judge the long-range significance of this reduction. However, there was no indication of recovery on any treated transect, and there is evidence that at least two plant species were substantially reduced as a result of treatments.

In attempting to examine the fate of individual species and their contributions to total cover (table 6), it was necessary to proportion cover estimates on the basis of recorded frequencies. Thus, if 15 percent vascular cover was recorded on 10 plots and 5 percent was identified as *Dactylus glomerata*, the remaining 10 percent was divided among other species according to their frequencies of occurrence. This calculation probably overestimates grass cover and underestimates forbs and small shrubs, but the general trends are considered adequate to evaluate species performance. The reader should also be aware that the averages for 11 transects presented in table 6 are lower than values actually recorded because, although some species were detected on all 11 transects, good development was usually confined to about half the samples.

*Vaccinium scoparium* was the most ubiquitous of the native low cover species on the burn. It was recorded with at least 0.7 percent cover on all transects and exceeded 25 percent on SC01. However, at least five transects received enough herbicide to produce major declines in *V. scoparium* cover. On the four undisturbed transects, vaccinium cover climbed steadily from 2 percent in 1964 to 7 percent in 1967 and 10 percent in 1973. By contrast, the seven disturbed transects also had 2 percent *V. scoparium* cover in 1964, but the species never exceeded 6 percent on any treated transect and the average for 1973 was only 1.4 percent.

*Lupinus sulphureus* was detected on eight transects but was of importance on only three. However, this legume species was very drastically reduced by herbicides. After providing cover in excess of 12 percent where it occurred and over 3 percent in all samples, it disappeared from two transects, dropped from 18 to 4 percent on the third transect, and made up less than 0.5 percent of all cover at the termination of the study.

Beargrass (*Xerophyllum tenax*) was detected on all 11 transects, but developed as an important cover component on only 5. On these five transects, beargrass cover was 2 percent in 1962 and nearly 6 percent by 1973. Development for this species was very consistent and appeared to take place independent of moisture conditions or herbicide effects.

Pinegrass (*Calamagrostis rubescens*) is usually considered an important component of the forest communities represented in the Sleeping Child burn. However, the species was recorded consistently on only 4 of 11 transects. The pattern of development is extremely interesting in that pinegrass cover rose from 0.3 to 2.0 to 3.5 percent in the first 3 years, remained at 3.5 percent for 2 years, and then climbed steadily to 11.6 percent in the 12th year. I assume that this pattern represents initial expansion via rhizomes, seed production for several years, and then a resumption of expansion via rhizomes of new plants developed from seed.

Fireweed (*Epilobium angustifolium*) produced some cover on every transect during the course of this study. However, only one transect had fireweed cover in every sample year of the study and the general patterns on different transects appear to suggest a 3- to 5-year cycle with local peaks around 2 percent and an average for the burned area of less than 1 percent fireweed cover.

Three species of carex were recorded in sample plots, and although all three apparently developed better at or above 7,000 feet, the only apparent difference among species was a suggestion that *Carex geyeri* grows earlier in the spring and is either more tolerant of moisture deficits or more responsive to excess moisture in April than *C. rossii*. In years when both April and May were dry (1966 and 1973), cover of *C. geyeri* increased while *C. rossii* was decreasing. Moisture excesses in April (1965 and 1967) resulted in proportionately greater cover increases for *C. geyeri*, while an April deficit followed by May moisture (1969) resulted in increases of *C. rossii*. Total cover for carex was about equally divided between these two species, with *C. concinnoides* appearing only on SC10 at less than 1 percent. The combined average for all transects shows carex stabilized at 1 percent in 1964, rising to 1.4 percent in 1967 and then stabilizing at 2.0 percent in 1969.

## Aerial Seeding

Of the management activities recorded on the Sleeping Child burn, the aerial seeding operation in 1962 was the only treatment for which no treated-untreated comparison can be made. Moreover, because no watershed studies were conducted on the burn, a direct evaluation of watershed protection is not feasible. Nevertheless, the seeded species were an important component of vascular cover during most of this study and their performance is of interest for several reasons. During the first growing season (table 6), two-thirds of all cover on the burn was produced by seeded species, and in the 12th season the failure of these species resulted in a substantial decline of vascular cover.

Of the six aerially seeded species, two had virtually disappeared by the fourth growing season. The annual rye grass (*Secale cereale*) provided slightly more than 1 percent cover on five transects below 6,800 feet in 1962 and was apparently able to produce a seed crop in 1963. However, 1963 was dry during April and May; and although 1.1 percent cover was again produced, the seed crop was very poor. Rye grass cover dropped to 0.1 percent in 1964 and the species virtually disappeared thereafter. *Trifolium repens* simply never succeeded. Although the species was recorded in 10 percent of all plots in the first year, it was effectively limited to three transects below 6,800 feet on which it briefly produced about 1 percent cover.

The four perennial grasses were more successful. Orchardgrass (*Dactylis glomerata*), in particular, produced over one-fourth of all vascular cover on the burn in 1966. This species increased from 1 percent cover in the first growing season to 8.9 percent through years 6 to 10. However, 2 dry years in a row and the development of native vegetation apparently resulted in a drastic decline to less than 2 percent cover in 1973. Chewing fescue (*Festuca ovina* var. *durescula*), on the other hand, has performed at a lower but more consistent level by producing 2 percent cover in the second growing season and continuing at that level throughout the study.

Timothy (*Phleum pratense*) also produced cover in the 2 to 3 percent range but dropped below 2 percent in 1966 and has continued to decline to less than 1 percent in 1973. The least successful of the perennial grasses was apparently smooth brome (*Bromus inermis*), which contributed 1 percent cover in the second year and remained below that level for the rest of the study.

For at least 10 years, then, aerially seeded domestic grasses contributed significantly to ground-level cover on the Sleeping Child burn. Increases from 3 to nearly 15 percent cover recorded during the first 6 years were followed by declines to less than 5 percent cover in the 12th year; but for most of this period one-half to one-third of all vascular cover on the burn was supplied by introduced species.

The contribution to total cover on the burned area suggests that seeded plants were strong competitors during the early stages of succession. The study reported here was not designed to detect whether such competition was great enough to influence development of native species, and I am accordingly indebted to Jack E. Schmautz, Henry C. Jacobs, and Don Williams[3] for the following information:

> During July 1962, tree seedling densities and cover by seeded grasses were tabulated on 80 quarter-milacre plots distributed in groups of 10 on north and south aspects with high and low grass cover. Plots were resampled in August and again in 1963 and 1964. The data show that during the single month in 1962 and annually for 2 years, tree-seedling attrition was greater where grass cover was high. For the 2 years of study, on plots with grass cover less than 1 percent, tree-seedling attrition was 6 percent annually on north aspects and 8 percent on south aspects. On plots where grass cover averaged 29 percent, seedling attrition was 31 percent on north aspects and 41 percent on south aspects. Seeded grasses significantly reduced survival of lodgepole pine seedlings on the Sleeping Child Burn.

Overall, the aerial seeding effort can be considered at least partially successful--but primarily for reasons other than those originally intended. Orchardgrass, chewing fescue, and timothy can be credited with major contributions to herbaceous cover on the burned area; but the fact remains that total cover was under 5 percent in the first year and only 18 percent in the second. During that period, the soil surface was vulnerable and protection may have been minimal by any standard. On the other hand, some reductions in lodgepole pine densities were achieved even though the residual stocking was still far in excess of acceptable timber management goals. And, finally, the 10 to 13 percent grass cover for a period of at least 8 years was the major component of a transitory range grazed by about 600 cattle each summer.

## Ecological Effects of Treatments

Although I have attempted to evaluate treatment effects by comparing disturbed and undisturbed transects, it is relatively obvious that the two groups do not provide a completely valid comparison. Only one of the undisturbed transects had tree densities approaching those on the treated areas; and, despite treatments that substantially reduced all forms of vegetation, the disturbed transects still averaged five times as many trees, three to six times as much shrub crown, and about twice as much vegetal cover as the undisturbed areas. Thus, even the most extreme deviation caused by treatments is probably within the range of normal variation for these high-altitude forest communities.

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[3]Northern Region, USDA Forest Service, Missoula. Data compiled by the Division of Range Management.

A minimum evaluation of treatments, then, would suggest no effect at all. This, in fact, appeared to be the case with respect to trees. There were several major reductions in tree-seedling density following pole sales and herbicide applications, but competition among seedlings could have been expected to produce substantial losses in these dense stands independent of outside influences. Examination of long-term attrition rates suggests that the primary effect of management treatments may have simply been short-term acceleration of an attrition that would have occurred anyway.

At the shrub level, an assumption that treatments had no effect seems less valid. Failure of the shrub component of treated forest communities to completely recover does appear to be a long-term adverse effect. Even though few shrubs were actually killed, recovery is not necessarily predicted because the trees are now tall enough to prevent full development of any species that is not shade tolerant. And, although most of the species involved are, in fact, relatively tolerant, the shrub component of treated forest communities is likely to remain below potential for a considerable period of time.

Reductions in vascular plant cover also appeared to represent a long-term adverse effect. Wherever disturbances occurred, vascular plant cover declined and a greater proportion of bryophyte cover was exposed. While this does not necessarily indicate that community structure and watershed protection have been permanently compromised, the existing plant communities are certainly more primitive and less productive than untreated communities would have been. Moreover, the loss or decline of several vascular plant species has, on some areas, resulted in less complex and presumably less stable biological communities. None of the Sleeping Child plant communities were particularly complex to begin with, and it is suggested that their ability to assimilate further disturbance may have been diminished.

Ecologically, the introduction of domestic grasses to the Sleeping Child plant communities had both positive and negative aspects. The increase in species diversity, particularly by plants resistant to herbicides, probably prevented even greater losses of vascular cover than those recorded. Also, the presence of any vegetation that stabilizes soluble nutrients on site must be considered an asset. Concurrently, however, additional competition from seeded species may have reduced the growth rate for native species as it did for trees and thereby prevented full development of cover by native species. In the long run, because introduced species have already declined from more than 50 to less than 20 percent in the total vascular cover and are apparently unable to compete with native perennials in dry summers, their eventual disappearance is predicted.

In an overall evaluation of the effects of management activity on the Sleeping Child plant communities, two points stand out. First, the various treatments applied did cause major modifications in plant community structure. The herbicide applications, in particular, resulted in substantial losses of shrub-crown and vascular cover. Despite these losses, however, the communities that have developed are not considered atypical. Second, the existing vegetation provides an impressive demonstration of assimilative capacity in plant communities that have remarkably low diversity.

# INDEPENDENT VEGETAL TRENDS

Although herbicides and other treatments changed vegetation on some transects, there were also fluctuations that appeared to occur independent of treatment. Summaries of vegetation change for all transects, without reference to treatments, demonstrate a consistency of pattern that provides a useful insight into early seral successional trends and plant responses to natural factors of environment.

## Shrubs

Annual changes in shrub volume, particularly in years with no management activity on the burn, were of special interest. In 1966 and 1973, for example, shrub volumes declined on most transects irrespective of location or treatment.

In an attempt to determine possible causes for these fluctuations, precipitation records for Darby, Montana, were examined for April through July of 1961 to 1973. Darby is located 14 miles west of the burn and 3,000 feet lower, but weather patterns are considered comparable even though actual precipitation at Darby is probably less than half that on the Rye Creek divide.

Precipitation at Darby averages just over 13 inches annually with a monthly distribution that is surprisingly regular. Only July and August average less than 1 inch of rainfall, and these dry months are preceded by 2 months averaging greater than 1.75 inches. Winter precipitation exceeds 1.50 inches only in November and December.

Despite the long-term regularity, Darby weather records show that local precipitation can vary considerably from year to year. Deviations from averages in excess of 0.5 inch per month appear to occur more than 50 percent of the time during the April to July season (table 7). Thus, plant growth, and particularly anthesis, could be substantially modified by deviations from average rainfall during the period of active growth and flowering.

Table 7.--*Deviation from long-term averages, precipitation at Darby, Montana, April through July, 1961 to 1973*

| Year | Succession year | April | May | June | July |
|---|---|---|---|---|---|
| 1961 | | 0.43 | 0.00 | -1.16 | -0.59 |
| 1962 | 1 | .17 | .09 | - .52 | - .24 |
| 1963 | 2 | - .18 | - .88 | 1.49 | - .71 |
| 1964 | 3 | .71 | .20 | 1.47 | .15 |
| 1965 | 4 | .66 | - .65 | .84 | - .25 |
| 1966 | 5 | - .69 | - .88 | .11 | - .65 |
| 1967 | 6 | .83 | .71 | .95 | - .33 |
| 1968 | 7 | - .27 | - .97 | - .30 | - .53 |
| 1969 | 8 | - .57 | .83 | - .33 | - .34 |
| 1970 | 9 | .09 | .14 | .61 | 2.11 |
| 1971 | 10 | 1.08 | 1.45 | - .79 | - .82 |
| 1972 | 11 | - .50 | - .91 | - .52 | - .60 |
| 1973 | 12 | - .76 | -1.18 | - .27 | - .47 |

In the relatively simple plant communities on the Sleeping Child burn there were only seven shrub species for which enough plants were recorded to constitute a major population on at least one transect. However, five of these species were recorded on no more than three transects and when exceptions due to disturbance are eliminated the samples are considered too small for analysis. Thus, there were only two shrub species for which the combined data from all transects could be examined.

*Spiraea*

Response of *Spiraea betulifolia* to fluctuations in precipitation is probably more pronounced than response of any other plant species (fig. 7). The bloom on spiraea is terminal and with our sampling technique usually adds 1 to 3 inches to plant height. Failure to bloom thus results in a shorter plant and a substantial loss of crown volume even if the plant remains otherwise healthy.

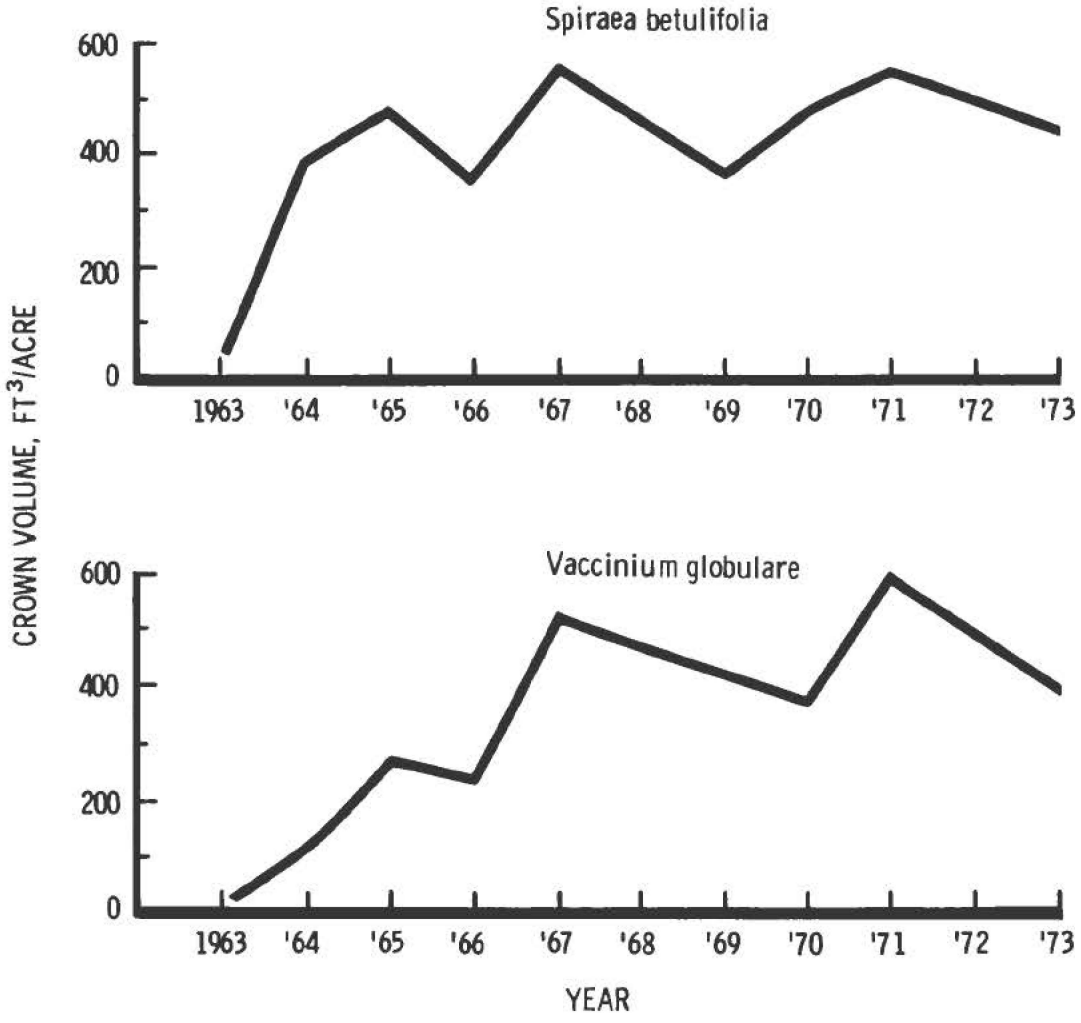


*Figure 7.--Annual changes in average crown volume per acre,* Spiraea betulifolia *and* Vaccinium globulare.

For the first two growing seasons after the fire, spiraea averaged less than 6 inches in height and was barely detected in the samples. In the next 2 years, growth was strong and volume increases substantial. In both years, this pattern corresponds to above-average precipitation in April. The dry May in 1965 apparently did not prevent successful growth initiated by moisture available in April.

Succession year 5 (1966) was dry, year 6 was wet, and the general growth pattern for spiraea was a decline followed by an increase. Years 7 and 8 were dry during April, and spiraea response was again a consistent decline. Moreover, the above-average moisture in May 1969 was apparently inadequate to reverse the volume decline initiated in April.

Years 9 and 10 were, respectively, moist and extremely wet during April and May; and spiraea crown volumes increased substantially during the 2-year period. Finally, the last 2 years of study had below-average precipitation and declines in spiraea crown volume were recorded throughout the burn.

In summary, fluctuations in crown volume for *Spiraea betulifolia* are highly correlated with moisture availability. April is probably the critical month in determining spiraea growth patterns. Inadequate moisture during May will not prevent spiraea anthesis initiated by April moisture; and precipitation in May will not reverse poor growth if April was dry.

*Vaccinium*

Responses of *Vaccinium globulare* to variations in annual moisture were similar to responses of spiraea (fig. 7), except that vaccinium had a greater tolerance to moisture deficits and exhibited greater response to excess moisture. Again, April moisture appeared to be critical. The single exception to vaccinium changes corresponding to April moisture occurred in 1970 when the effects of herbicides depressed vaccinium crown-volume averages even though an increase might have been predicted.

## Species Frequencies

The plant communities on the Sleeping Child burn are relatively simple. Even the most complex transects produced fewer than 20 species in the ten 2- by 2-foot sample plots, and there was no study site on which 40 species were recorded as present. Transects averaged 9.3 species 1 year after the fire. Five additional species (14.1) were recorded on an average transect by the eighth growing season, and for the last 4 years of study the average was 13.0 species per transect.

A few plant species did occur on enough transects to justify examination, but the general paucity of vegetation suggests that combining species into broad plant groups might provide a better evaluation of long-term trends. Table 8 expresses the average combined frequency of occurrence for eight major plant groups on 11 transects as the probability of finding a representative of the group in a random sample plot. The effects of high frequencies for several species in a group are evident in the "introduced-grasses" category with the probability that more than one species representative will be found in a single plot. These data are also graphed in figure 8.

These frequency data indicate several significant trends. All plant groups had stabilized by the fourth postfire growing season and only the native-graminoids category increased after that time. This pattern is consistent with the hypothesis that community composition is determined in the first few years of seral development. Increases in native graminoids were primarily due to rhizomatous growth of pinegrass and two species of carex.

Table 8.--*Probabilities of occurrence in sample plots for eight plant groups on the Sleeping Child burn, 1962 to 1973*

| Plant group | Succession year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| Trees | 0.45 | 0.52 | 0.53 | 0.52 | 0.54 | 0.55 | -- | 0.53 | -- | 0.38 | -- | 0.34 |
| Shrubs | .20 | .56 | .85 | .92 | .96 | .94 | -- | .92 | -- | .91 | -- | .98 |
| Native graminoids | .17 | .28 | .37 | .42 | .40 | .42 | -- | .55 | -- | .58 | -- | .67 |
| Introduced grasses | 1.53 | 1.95 | 1.98 | 1.91 | 2.02 | 2.07 | -- | 1.95 | -- | 1.72 | -- | 1.36 |
| Native forbs | .25 | .35 | .61 | .67 | .65 | .72 | -- | .67 | -- | .71 | -- | .69 |
| Introduced forbs | .10 | .05 | .02 | -- | -- | -- | -- | .01 | -- | .01 | -- | .01 |
| Native annuals | -- | .02 | .06 | .04 | .06 | .07 | -- | .06 | -- | .08 | -- | .09 |
| Introduced annuals | .52 | .07 | .01 | -- | -- | -- | -- | .01 | -- | -- | -- | -- |

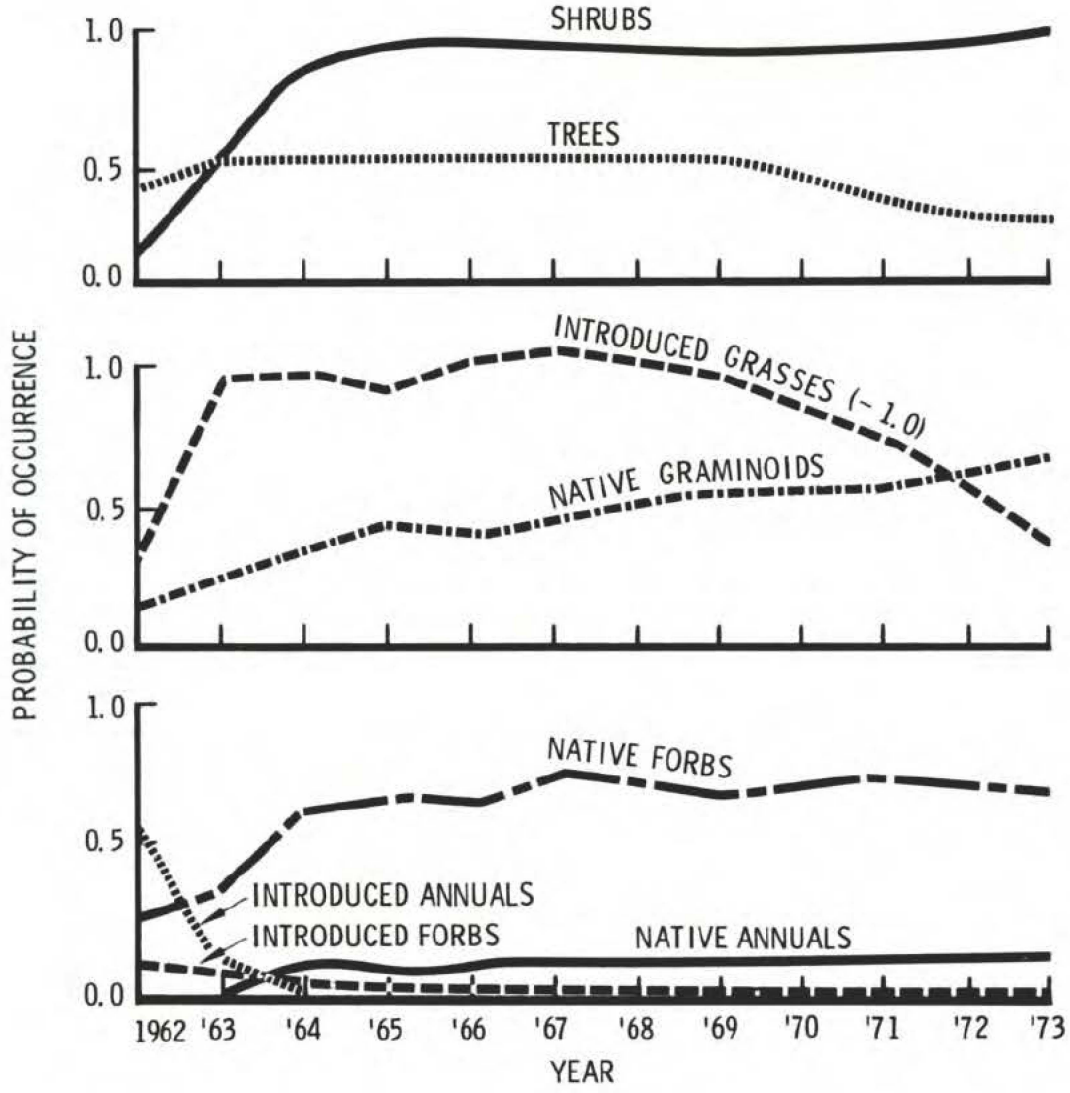


*Figure 8.--Probabilities of occurrence in sample plots for eight plant groups on the Sleeping Child burn, 1962 to 1973.*

Although tree densities did drop during the study, the decline in tree frequencies after the eighth year is probably a sampling artifact related to the height limit for woody vegetation. Once a tree reached 18 inches, it was no longer counted in the frequency plots. Although the same artifact would eventually appear in shrub samples, it has not because the majority of shrubs on the Sleeping Child burn were less than 1 foot tall even after 12 growing seasons.

Comparison of the frequencies for introduced and native graminoids reveals that the introduced species were relatively successful but are now on the way to becoming less important in the plant community. While graminoids have increased consistently since the burn, the introduced species began to decline in frequency after 1967.

In a somewhat similar pattern, native forbs and annuals have had constant or slightly increasing frequencies throughout this study, while introduced forbs and annuals have virtually disappeared. Most of this change is associated with the Dutch white clover (*Trifolium repens*) and annual rye (*Secale cereale*), which were seeded for watershed rehabilitation.

# SUMMARY AND CONCLUSIONS

In the year following the 1961 Sleeping Child forest fire, 12 permanent transects were established within the burned area to provide the basis for a long-term study of postfire vegetal succession. Eleven transects were sampled annually through 1967 and semiannually through 1973. Data collected included tree density; shrub-crown volume; and cover and frequency of occurrence for herbaceous and low woody species.

During the 12 years of study, all but two transects were disturbed in one or more ways by management activities; and by 1973 only four transects were considered to have developed nearly normally. However, even though the original study objectives had been compromised, the available data do represent a series of case studies summarizing the development of vegetation following wildfire and modified by the apparent effects of superimposed management activities.

Management programs on the Sleeping Child burn have included a wide variety of treatments intended to prevent watershed deterioration, salvage wood fiber, reduce tree-seedling densities, and relieve grazing pressure on other parts of the Bitterroot National Forest. Chemical thinning of tree seedlings, and to a lesser extent, pole sales and cattle grazing had marked effects on individual transects, but there was also a discernible pattern of vegetal development independent of treatment effects.

Tree-seedling densities averaged more than 34,000 per acre in the first few years following the Sleeping Child fire, but by the 12th growing season, the average tree density had dropped below 18,000 per acre. The survival rate on seven treated and four untreated transects was nearly identical, however, and the data suggest that the proportion of dominant trees was determined by competition among seedlings rather than the treatments applied.

Shrub-crown volumes averaged 2,076 $ft^3$/acre on 11 transects in 1973, but 7 transects suffered substantial reductions, mostly as a result of herbicide applications. Crown dieback was concentrated in alder, *Vaccinium globulare* and spiraea; and while there is little evidence that the plants affected were permanently removed from the forest community, there is also little evidence that shrub-crown deficits will ever be recovered.

Average vegetal cover on all transects reached nearly 60 percent by the 10th postfire year, but treatments substantially modified the structure of this low vegetation by reducing the proportion of total cover represented by vascular plants. *Vaccinium scoparium* and *Lupinus sulphureus*, in particular, were very adversely affected by herbicide applications.

Vegetal cover on the Sleeping Child burn was only 4 percent in the first season, but two-thirds of this cover was produced by introduced species. Annual rye grass and Dutch white clover had virtually disappeared by the second year, and smooth brome performed very sporadically; but orchardgrass, chewing fescue, and timothy contributed 30

to 50 percent of the low vascular cover on the burn for at least 8 years. Eventual dominance by native species is suggested by the decline of introduced species to less than 5 percent cover in 1973.

Plant community structure was modified by management activities, but none of the existing Sleeping Child forest communities are considered completely atypical. Despite the remarkably low level of biological diversity, these high-altitude communities appear to have a high capacity to assimilate disturbance.

For two shrub species, *Spiraea betulifolia* and *Vaccinium globulare*, data are adequate to suggest a relatively strong year-to-year response in growth associated with spring moisture conditions. Spiraea, in particular, appeared to respond to April moisture; vaccinium was responsive to any spring moisture and tolerant of moisture deficits.

Long-term trends in species frequencies indicate a relatively early stabilization of plant community composition following fire. Introduced forbs and annuals disappeared within 2 years and only the graminoids showed substantial changes in frequency after the fourth postfire growing season. In general, native species were still increasing in the 12th year while introduced grasses were disappearing.

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